

**DEVICE FOR CONTROLLING AND/OR MONITORING
EXTERNAL TECHNICAL PROCESSES**

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This is a Continuation of International Application PCT/DE99/02940, with an international filing date of September 14, 1999, the disclosure of which is incorporated into this application by reference.

FIELD OF AND BACKGROUND OF THE INVENTION

5 The present invention relates to a device for controlling and/or monitoring of external technical processes, in particular a device for use in connection with safety-related controls. The device has an input function, an output function and a processing function and can be connected to at least one higher-level unit for transfer of process-influencing and/or process-monitoring signals to actuators and/or sensors by way of a bus system.

10 A programmable controller that can operate alone with an input, an output and a processing function is known from European Patent EP 0 499 675 B1.

Field bus systems or peripheral bus systems that are on the market today can be used only in a limited way for time-critical safety applications because they have undetermined or unacceptably long response times. To date, known applications of the communication
15 medium have the disadvantage that signals for the fast reactions required to ensure safety or security cannot be transferred at the required speed from the central unit over the bus to the decentralized peripheral stations. This is because the guaranteed response time over the bus exceeds the time required for fast reactions. In this process, the guaranteed response time over the bus includes at least the signal run times over the bus and the processing time
20 required by the central unit. In turn, the central unit processing time is composed at least of evaluating the bus protocols; plus the time for evaluating the input signals and for calculating the output signals.

OBJECTS OF THE INVENTION

An object of the present invention is to decrease the reaction time of the process control with respect to alarm signals received from the process that are critical to safety or security.

SUMMARY OF THE INVENTION

This and other objects are solved by means of a device for controlling and/or monitoring an external technical process, in which the processing function of the device executes logical links. The results of these logical links are available for the process control and/or process monitoring after expiration of a time interval that is shorter than the response time of the communication and the higher level unit. In this process, these results are evaluated by the device itself for triggering operation of an actuator.

In many automation processes an immanent asymmetry exists between, on the one hand, logically deep functions, e.g. switch-on functions with long calculation times and slow-request switch-off functions (for example in two production lines, a stop of the first production line should cause a 'slow stop' of the second production line) and, on the other hand, logically flat shut-off functions with short calculation times. It is precisely this asymmetry that the device according to the preferred embodiment of the present invention is directed. This is because the logically flat shut-off processes can be processed by the device itself using the internal processing functionality, while signals relating to switch-on processes continue to be processed by the higher-level unit. These are then sent over the bus from the higher-level unit to the process and from the process to the higher-level unit. Logically deep functions include complex functions, in particular those that require a lengthy series of logical operations to achieve the calculated result. Logically flat functions, on the other hand, are more simple functions requiring only one or few calculation steps.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention and further advantageous refinements of the invention according to the features of the dependent claims are explained in more detail below with the aid of the diagrammatic, exemplary embodiments in the drawings, in which:

5 FIG 1 is a functional block diagram of a system used, e.g., in a manufacturing line, illustrating a first embodiment of the invention;

FIG 2 is a functional block diagram of all or part of a module according to a second embodiment of the invention; and

10 FIG 3 is a functional block diagram of all or part of a module according to a third embodiment of the invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

15 The arrangement shown in Figure 1 contains a higher-level programmable controller in a central frame 8 with a central unit 5 and an associated power supply 10 that generates the required extra-low operating voltages from a network power supply. A field bus 4 is controlled by the integrated bus interface 11 of the central unit 5, operating as a bus master. In addition, the arrangement contains one or more expansion frames 9 which each contain a bus coupling module 7, peripheral modules, not shown, for standard actuation and/or monitoring of an external technical process, as well as, the device 1 according to the invention. The device 1 is designated in the following description as a mixed module 1 for short because of the integration of input, output and processing functions. The mixed module is connected to one or more actuators 3 and/or sensors 2.

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For example, a punch for a hydraulic press can be set into operation by actuation of an actuator 3. The logical links needed for this are essentially carried out by a central unit 5. To

do this, the central unit 5 has available to it, in particular, data from other decentralized peripheral stations for linking. For example, this can be used in sequential processing of the respective work pieces in a manufacturing line.

A sensor 2 is provided to implement an emergency-off function, which according to the embodiment makes a fast shut-off of the hydraulic press possible in the case of a malfunction or hazard. An application like this requires that the press be shut off within a specified time. In order to fulfill this safety function, the time specified should be, e.g., less than 10 ms.

The undetermined reaction time (or relatively slow, e.g., >30ms reaction time) over the field bus 4 does not guarantee this shut-off time. Thus, according to the present invention, the processing of the input signal received from the sensor 2 in the case of a malfunction or hazard takes place in the mixed module 1 itself. In the simplest case, this is a matter of an IF-THEN link that will shut off the actuator 3 as soon as an input from the sensor 2 is present. In other words, the processing function of the mixed module 1 is enhanced for processing corresponding logically "flat" links.

Since a logical link of this type occurs in the mixed module 1, independently of the bus cycle or of the cycle of central unit 5, a quasi-immediate shut-off of the actuator 3 is ensured. In this process, the time difference between actuation of the sensor 2 and shut-off of the actuator 3 is essentially specified by the internal cycle time of mixed module 1. Because of the logically flat links that the mixed module 1 processes, this time is very short in comparison to the combined reaction times of the bus 4 and the central unit 5. As a result, a fast reaction shut-off is ensured by the mixed module 1.

Basically, the function of the mixed module 1 does not differ from the function of a so-called compact control, i.e., of a control with processing function. For example this may

be the control of a CPU in a more powerful memory programmable controller. However, in a compact module such as this, input and output functionalities are provided directly. In a CPU with expansion modules, the input and output functionalities are reserved for the respective input or output modules.

5 The module 1 preferably contains a relatively small number of logic functions, time function elements and/or comparators, etc. The logical links are preferably programmed by the end user. The logic operations are carried out by means of, e.g., a microprocessor or a programmable logical unit (programmable array logic PAL / ROM / EEPROM, solid-state elements, etc.). The module 1 can be coupled to the bus 4 either directly or indirectly as a
10 sub-component of an element such as expansion frame 9. In addition, it is readily possible to design the arrangement so that signal states within the module 1, as well as inputs and outputs thereof, can be provided to the higher-level unit, for monitoring purposes.

15 Figures 2 and 3 show two variants of a simple mixed module 1a, 1b. In the case of mixed module 1a in Fig. 2, an AND gate 20 has a first input 11 from the central unit 5 and a second input 12 directly from a switching sensor 2a, shown here in the closed position. Under normal operating conditions, both of the inputs 11 and 12 will be in a logic "1" state and the actuator 3a will be in operation as well. However, whenever either of the input signals becomes a logic "0", then the logic gate 20 sends an output 13 to the actuator 3a to immediately cease operation and come to a standstill. The higher level input is typically the
20 result of complex computations relating to the operational states of associated tools and units on the same manufacturing line. Such associated units include, e.g., units that deliver parts to a machine press 3a. Thus, the central unit 9 typically is provided with data defining the current processing states (e.g. manual, automatic, current status of neighboring and associated units, etc.) and is programmed to process all the controlling and monitoring functions that can

be carried out safely even with relatively slow reaction times (e.g. > 30ms). However, any applications that require shorter reaction times, in particular those relating to safety, are processed directly in the module 1a. For instance, the sensor 2a may be either an optical sensor (e.g. light barrier) that detects that an operator's limb has inadvertently entered the hazard area of a machine press, or a mechanical emergency foot pedal. In either case, triggering of the sensor 2a produces a signal change on the local input line 12, which is processed locally in the mixed module 1a, in order to stop the actuator 3a as rapidly as possible. The actuator 3a may be, e.g., a motor drive of a machine press or a robotic drive.

Fig. 3 shows yet another variant of a simple module 1b. Here, the output of a sensor 2b is supplied via signal line 12 to one input of a comparator 30. The comparator 30 compares the sensor signal 12 with a signal value input via signal line 11 and outputs an actuator control signal 13 accordingly. The signal value input 11 may originate, e.g., from the central unit 5, or, alternatively, may be a signal state originating within the mixed module 1b.

The above description of the preferred embodiments has been given by way of example. From the disclosure given, those skilled in the art will not only understand the present invention and its attendant advantages, but will also find apparent various changes and modifications to the structures and methods disclosed. It is sought, therefore, to cover all such changes and modifications as fall within the spirit and scope of the invention, as defined by the appended claims, and equivalents thereof.